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13. ABSTRACT *(Maximum 200 words)*

This report summarizes the final progress on an investigation into an engineering-oriented approach for design of distributed-object software. The key results of the research are highlighted, including works published and personnel supported.

14. SUBJECT TERMS

software engineering, distributed computing, Petri nets, object modelling

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Final Progress Report
Author/PI: S. Shatz

Statement of Problem Studied:
This research investigated an engineering-oriented approach for design of distributed-object software.

Summary of the most important results:

We developed a couple of results related to the use of Petri net-oriented models for design specification. For our State-Based Object Petri Net model (SBOPN), we demonstrated how to create models that support class-level models with instantiation rules to generate object-instance models, and how to synthesize models for objects with restricted behavior from more general ("superclass") models. We also proposed a framework for using the SBOPN notation as a basis for formal modeling of Aspect Oriented systems. We also expanded the SBOPN notation and developed templates of basic object components, defining a set of modules for plug-and-play modeling of a distributed software architecture. Finally, we formulated a scheme for translation of UML diagrams (Statecharts and Collaboration Diagrams) to an object-based Petri net format that can support design simulation and analysis. We are currently developing a prototype tool to demonstrate this capability.

We also developed a new line of research into modeling of agent-oriented software systems. To this end, we defined extensions to the G-net model (an existing object-based Petri net model) and developed a special-purpose agent-based G-net model. We used existing net theory to prove some properties of our agent-based model. In addition, we extended our agent-based model to include inheritance features, creating an agent-oriented model, and used some existing net tool to analyze the model.

Publications:

(a) Journals:

J. Saldhana and S. M. Shatz, "Formalization of Object Behavior and Interactions From UML Models," Accepted pending minor modifications to the *International Journal of Software Engineering and Knowledge Engineering*, 2001.

(b) Peer-reviewed Conference Proceedings

H. Xu and S. M. Shatz, "A Framework for Modeling Agent-Oriented Software," To appear in the *Proceedings of the IEEE 21st International Conference on Distributed Computing Systems* (ICDCS), Phoenix, Arizona, April 2001.

H. Xu and S. M. Shatz, "An Agent-Based Petri Net Model with Application to Seller/Buyer Design in Electronic Commerce," To appear in the *Proceedings of the IEEE 5th International Symposium on Autonomous Decentralized Systems* (ISADS), Dallas, Texas, March 2001.

M. Lemmon, K. He, and S. M. Shatz, "Dynamic Reconfiguration of Software Objects Using Petri Nets and Network Unfolding," *Proceedings of the IEEE Int Conf. on Systems, Man, and Cybernetics* (SMC), Nashville, Tenn., Oct. 2000, pp. 3069-3074.

H. Xu and S. M. Shatz, "Extending G-Nets to Support Inheritance Modeling in Concurrent Object-Oriented Design," *Proceedings of the IEEE Int Conf. on Systems, Man, and Cybernetics* (SMC), Nashville, Tenn., Oct. 2000, pp. 3128-3133.

X. Xie and S. M. Shatz, "An Approach to Using Formal Methods in Aspect Orientation," *Proceedings of the Int. Conf. on Parallel and Distributed Processing Techniques and Applications* (PDPTA), (Special Session on Architectural Support for Aspect-Oriented Software Systems), Vol. 1, June 26-29, 2000, Las Vegas, Nevada, pp. 263-269.

J. Saldhana and S. M. Shatz, "UML Diagrams to Object Petri Net Models: An Approach for Modeling and Analysis," *Proceedings of the Int. Conference on Software Engineering and Knowledge Engineering* (SEKE), Chicago, July 2000, pp. 103-110.

(c) Manuscripts submitted, but not yet published

X. Xie and S. M. Shatz, "Development of Class-Level and Instance-Level Design Models for Distributed-Object Software," Submitted to *Int. Journal of Computer Systems Science and Engineering.*

H. Xu and S. M. Shatz, "An Approach to Using Formal Methods in Agent-Oriented Design and Analysis" (to be submitted to the IEEE Transactions on Knowledge and Data Engineering).

X. Xie and S. M. Shatz, "Design Models for Components in Distributed Object Software," Submitted to the 2001 Monterey Workshop on Software Engineering.

Scientific Personnel:

X. Xie completed his PhD degree in 2000.
H. Xu is a continuing PhD student, expected to complete in Fall 2001.
4 other students participated on the project (non-pay) and completed MS degrees.

Report of inventions: None to report